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THE FOUNDRYMEN'S ASSOCIATIONS.

At the April meeting the regular paper was contributed by H. O. Evans on "The Shrinkage of Malleable Iron Castings."

SHRINKAGE OF MALLEABLE IRON CASTINGS.

By H. O. EVANS, with Thomas Devlin & Company, Philadelphia.

In the paper by Mr. Davis on "Annealing Malleable Cast Iron," read before this association at its March meeting, the subject of allowance for pattern shrinkage was alluded to.

In a critique of the above paper, written by Dr. Moldenke and read before the Pittsburg Foundrymen's Association as a discussion of Mr. Davis' paper, the author says:

"The expansion taking place during anneal is well known, and allowed for in making the patterns. It may be taken as a general rule that the contraction of the chilling irons used for "malleables" is $\frac{1}{4}''$ to the foot. In the anneal an expansion of $\frac{1}{8}''$ to the foot takes place, the net result being the ordinary contraction allowed for gray iron. Patterns are therefore made in the usual manner. The special art of the "malleable pattern" maker being shown in the gating, and chill arrangements, etc."

Now as the writer was, at the time Mr. Davis' experiments were made, superintendent of that foundry, he may be pardoned if he uses some of Mr. Davis' figures to controvert the "net result" arrived at by Dr. Moldenke as a guide for the "malleable" pattern maker. The writer's opinion has been since he first en-

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countered the problem in '86, that the "pattern shrinkage" on malleable castings is the greatest variable known since x, y and z were first used to denote such a quantity, and in this we are glad to have Dr. Moldenke's support, as where he states "contraction and expansion are not regular," and "long malleable castings can therefore show some unexpected features." The reason for this he ascribes to the following three causes:

1. Changes in chemical composition of the iron.
2. Casting temperature.
3. Shrinkage in interior.

To these the writer would add a fourth: Annealing temperature and length of anneal. On examining these causes we find that all of them are practically beyond the control of the pattern maker, who is carefully held to drawing dimension with rule and caliper.

In dealing with this question we will do well to divide it into the two natural stages as they occur.

1. The shrinkage, or, more properly, contraction, due to cooling in the white iron casting.
2. The expansion, the result of annealing.

The composition of the iron we will leave to the chemist. The temperature of casting and chilling arrangements to the foundry foreman.

Of contraction in the first stage the commonly accepted rule is $\frac{1}{4}''$ to the foot, and this result is borne out by table No. 3 in Mr. Davis' paper, from which I quote:

Size Bar.	Pat. Length.	White Iron Length.	Annealed Length.	Contraction.	Expansion.	Net Contraction.
$\frac{1}{8}$x1	12.000	11.768	11.832	.232	.064.	.168
$\frac{1}{4}$x1	12.000	11.784	11.930	.216	.146	.070
$\frac{3}{8}$x1	12.000	11.757	11.927	.243	.170	.073
$\frac{1}{2}$x1	12.125	11.909	12.093	.216	.184	.032
$\frac{5}{8}$x1	12.000	11.742	11.942	.258	.200	.058
$\frac{3}{4}$x1	12.000	11.769	11.964	.231	.195	.036
Average				.232	.156	.076

In this experiment the patterns were accurately made on a board, four to each set, were drawn without rapping, and poured

from one ladle, with the exception of the ½" bars, which were our regular test, and poured as usual, being given three days' annealing at a moderate heat. The iron analyzed silicon 0.60, sulphur 0.047, total carbon 3.23.

Referring to results, we see that the average contraction, result of 24 measurements is within .018 of assumed contraction, which is very close, and here would call attention to the fact that the maximum variation from average is only .026, the extremes differing only .042, showing that for all thicknesses the contraction is very uniform, at least, when, as in this experiment, the fractures show complete combination.

In the second stage of expansion we note an average expansion of .156, a result which is nearly 25 per cent. greater than allowed by Dr. Moldenke, and we also note that the maximum variation is .092 with a difference between extremes of .136 more than ⅛", a not unusual result, and indicating that the source of greatest variation is to be found, as a result of the annealing. "That a remarkable change" does take place during annealing I agree with Dr. Moldenke, but I differ from him when he says "that removal of carbon in the skin is but a small matter, for the fact that we can largely remove it from light sections, confirms the view that it is to that element we must look for a cause for the expansion that occurs during annealing.

For purposes of comparison we will arbitrarily divide the figures of table into divisions, those of ⅜" thickness and below, and those above, 3-16 inch, being the greatest depth from which carbon is largely removed, and I quote Mr. Moldenke's experiment to prove this where he planed the ⅝" bar, with broken ends, off by sixteenths with following results:

Total C. hard iron 4.08; after annealing first sixteenth contained 0.16, C. second, 0.65; third, 1.84; fourth, 3.97; fifth, 4.05. You will note that at a depth above 3-16ths the carbon extracted is very little, and shows some basis for the old rule that ⅜" was the thickest you could get good malleable.

Tabulating under this classification, we note:

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First Class (Carbon extracted.		Net Contraction.
⅛ bars expansion,	.064	.168
¼ bars expansion,	.146	.070
⅜ bars expansion,	.170	.073
	.380=Average .126.	.311=Av. .103
Second class (Carbon present).		Net Contraction.
½ bars expansion,	.184	.032
⅝ bars expansion,	.200	.058
¾ bars expansion,	.195	.036
	.579=Average .193.	.126=Av. .042

The average in first class is .126 and in the second .193, or 50 per cent. more than the lighter section, and the only assignable reason the writer can submit is that the carbon present as graphitic or temper carbon must cause castings to assume larger dimensions in the molecular rearrangement which occurs during the anneal, but from whatever cause the experiments show and the result is in consonance with writers experience, that contraction to be allowed for is largely dependent upon thickness of section.

It is obvious that with so many causes for variation, no hard or fast rule can be made to apply, but the following rules are what the writer recommends for general use: For light sections, ⅛″ to 1-16″ per foot; for heavy sections, above ⅜″—1-16″ to 1-32″ per foot; for cored holes, have print exact size up to say 2″ diameter, above use same rule as for rest of pattern.

For a pattern of heavy section that is rapped for drawing make exact size. The writer has followed this rule on castings 2 feet in length with excellent results. The only positive rule to be given is try every pattern before going ahead. In conclusion, would say that in a business that calls for close attention I know no department which requires a longer experience in malleable casting than the pattern maker's and that "the special art" of the malleable pattern maker is shown in other ways, besides the gating and chilling arrangements.

That results will differ in every shop is evinced by a remark a mechanical engineer, in charge of drawing room and pattern shop

of a railway which is a large consumer of malleable, made to writer when asked what shrinkage he allowed, he said: "It is almost impossible to figure shrink. We send the same patterns to different shops and get a different casting from every one." Whether there be purpose in this madness I wot not.

Admitting the difference, we leave it an open question as to why. Trusting that time and experience may reconcile all differences.

At the Philadelphia meeting Edward Kirk read the following paper entitled:

SHOULD A FOUNDRY CHEMIST BE A PRACTICAL MELTER AS WELL?

When visiting foundries in different sections of the country I have learned that but a very small per cent of them employ chemists, and the reason for not employing them is largely due to the system adopted by the advocates of chemistry in placing the matter before foundrymen.

This has been done upon the theory that it is only necessary for the founder to have an analysis of his irons to enable him to produce castings of any degree of hardness, softness and strength desired, which in many instances has not been the case.

This system seems to me to be entirely wrong, and certainly has been productive of a prejudice against the employment of chemists in foundries. By this system the founder is compelled to make his mixtures from analysis, something in which he is not experienced, and is responsible for results.

The question that many founders have asked is, Why should we employ a chemist, when we have the same work to do and responsibility as without one, and no greater certainty of results?

It is a well established fact that the quality of an iron may be greatly deteriorated when melted in a cupola by improper melting. And the results indicated by analysis may be entirely destroyed in this way, and with the present system of the chemist only furnishing analysis, the science of chemistry is placed entirely at the mercy of the melter, who can destroy its aim at will and

who frequently does destroy it, either through ignorance of the proper management of a cupola or prejudice against chemistry.

To relieve the founder of responsibility in making mixtures and make the chemist of greater value to him and also to place the chemist in a position independent of the melter and make him master of his science, I propose that the chemist be given full charge of the mixing of iron and of the cupola and melter, that he be held responsible for the results of his analysis at the cupola spout.

To prepare the chemist for the work, I propose that a course in practical foundry chemistry be established by colleges, giving a course in metallurgy, or by mechanical training schools, that will make the chemist a practical melter and an expert on cupola management, as well as a chemist. And when employed in a foundry he should be given full charge of the cupola and mixing and melting of irons.

I do not propose the chemist be required to do the laborious work of melting, but that he be given full charge of the cupola and melter, with power to discharge the melter if he does not follow his instructions in managing a cupola.

By this system the cost of melting in many foundries could be reduced to a sufficient extent to more than pay the salary of a chemist, more satisfactory melting done and better castings produced.

This would be an inducement to the founders to employ chemists, and more advancement would be made in foundry chemistry in one year than has been made in the past ten years with the present system.

I desire to place this matter before the Foundrymen's Association for their consideration as a practical means of increasing the employment of chemists in foundries.

A talk on Africa, illustrated by over 60 stereopticon views, by Jas. H. Birch, of Burlington, N. J., proved a most interesting event, a vote of thanks being tendered Mr. Birch after the lecture.

A buffet lunch was served at 10:30 o'clock, at which a num-

ber of impromptu speeches were made. Mr. Rankin, the president, called the attention of the association to the rapidly increasing membership of the labor unions, and of the boast of the Molders' Union that Philadelphia shops were unionized almost to a man.

L. Tack, a Roumanian iron founder, gave a brief outline of the conditions existing in his native land, and contrasted the great differences in prices of fuel, wages, etc., in America and Roumania.

The maintenance of prices was the theme chosen by E. E. Brown, and a continuance of the same subject, together with the ruinous practice of selling goods without a positive knowledge of their manufacturing cost, was dwelt upon by W. H. Pfahler, who also briefly stated the benefits derived from membership in foundrymen's associations.

E. S. Cook, of the Warwick Iron Company, spoke of the progress of chemistry in the foundry and blast furnace, the subject being very appropriate owing to the reading of Dr. Kirk's paper at this meeting. Mr. Cook's opinion was that in his experience the average chemist was not a practical melter.

A. C. Pessano referred to the strength of the Molders' Union and the protection afforded members of the National Foundrymen's Association against the demands of organized labor.

At the Pittsburg meeting, Dr. Richard Moldenke gave an interesitng address on fire clay, from which we present the following:

Refractory material may be divided into three classes: 1, acid refractory material, including clay, of which silica fire brick are made, the material in this case being silicate of alumina; 2, neutral or chrome or red brick, of which the main ingredient is chromate of iron; 3, basic refractory material or magnesite, of which the main ingredient is carbonate of magnesia.

In order to explain the existence of these different materials it will be necessary to go a little into geology. In early geological times clay resulted from the decomposition of granite

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and was composed of quartz, feldspar and mica. The clay gradually decomposed and the mica was washed away. Later on the quartz was washed away also, and the feldspar which was left became soft and constitutes what is now called kaoline. Primary clays all have more or less mica and quartz still mixed in them. When the clay has been thoroughly washed in this manner it is mainly pure, but the clays as found are of widely varying grades of purity. There is also a variety of clay which has been formed from the decomposition of sandstone, and this clay contains grit. Another variety is formed from resolved limestone. This is found in the pot holes of Kentucky, the bed being usually composed of a limestone containing about one-third clay and two-thirds carbonate of lime. This clay is not good as a refractory material, but is excellent for pottery works. In our work we want one little corner in this classification of clay—the best. The qualities to be considered in selecting a refractory material for foundry work are shrinkage, plasticity, corrodibility and liability to abrasion, while the composition must also be taken into account. Some varieties of brick expand in use, while others shrink, and the best brick would be one that combines these two qualities in equal proportions, so that it would remain unaltered in use. One way to reduce the shrinkage is to add to the clay mixture ground burnt brick, which has, of course, already gone through the shrinking process. The fineness of the grain of the brick has a great deal to do with its ability to resist corrosion. Again it is suggested that in lining the cupola it would be well to use different kinds of brick at different heights. The glazed brick will resist abrasion or wearing away the best of all, but this brick is very likely to spawl off, and on that account cannot be used.

There is a wide range in the composition of different clays, the finest variety being that which is used in crucible steel making and the poorest being the common red brick, although the adobe of which many houses in Mexico are built might also be included and would come below the red variety. This adobe is composed of 50 per cent lime and 50 per cent clay. In refractory brick for metallurgical purposes it is necessary that the impurities

shall not exceed 5 per cent, the most important of these impurities being lime, magnesia and soda. In pottery clay there is between 2 and 3 per cent of lime. This alone would unfit it for use as a refractory material. In the red clay there is sometimes 7 per cent of iron, and chemists are frequently called upon to assay this red clay by parties who think they have found commercial deposits of iron ore.

At this point Dr. Moldenke exhibited several samples of clay from Klingenburg, Germany, which were remarkably pure.

In examining clay to determine its adaptability as a refractory material the physical property should first be investigated. The color should be noticed. A sample should be powdered and the manner in which it calcines noted. The fracture should then be examined whether smooth or rough, etc. Then the texture should be noted. Next the specific gravity should be determined, the dense clays having a specific gravity of over 2, while the lighter clays have a specific gravity even under 1.75. It is well to consider these matters, as in some cases it is possible to mix some of the lighter clay in with the heavier and still obtain a sufficiently high specific gravity. Next it is well to slack the sample by putting it in water and noting how fast it is acted upon. The size of the grains coming off should also be watched and the water should be felt to determine whether there is any grit present.

In examining for plasticity a sample is put into water, which makes it plastic. The quantity of water required to produce plasticity should be observed. The sample exhibited required only 31 per cent of water to make it plastic, which is very satisfactory. The less water required the better, because all this water which is put in the clay to make it plastic must come out of it ultimately, and this produces shrinkage. The strength of the clay under pressure should next be noted. The sample exhibited withstood a pressure of 150 pounds per square inch. Some clays will only stand 30 or 40 pounds to the square inch. The shrinkage in the brick should be noted in two stages; first, the air shrinkage, by drying the brick in air, which amounted to 9 per cent in the case

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of the Klingenburg clay, and then the shrinkage by slowly calcining, which amounted with the Klingenburg clay to 7 per cent, making a total shrinkage of 16 per cent.

In examining into the vitrifying qualities, the sample should be heated to a temperature as high as possible and very slowly. The highest temperature which the speaker had been able to secure was 2,700° F. This had been secured by using a muffle with natural gas and hot air at 2,700° F. The Klingenburg material showed the edges slightly rounded. Besides noting the tendency of the edges to become round, a piece should be supported at the ends and the amount of sag in the center should be observed. A sample of Kentucky brick sagged considerably under such treatment and the edges became very round. For annealing furnaces the amount of heat which the brick will stand is not of nearly as much importance as in steel melting, and by observing this point it is sometimes possible to save $4 a thousand in the cost of the brick. There is also what is called a "rational analysis," where an investigation is made to see how pure the clay is, an examination being made for mica, etc.

Some discussion followed this talk, in which the speaker was called upon to answer many questions not only concerning fire clay, but fire brick and material for linings generally.

Benjamin D. Fuller followed Dr. Moldenke with some of his experiences as a foundry foreman, of which he said:

That "it takes all sorts of people to make a world," is an old saying, and I know of no better place to see this old adage in its true light than in a foundry. Watch a molder for an hour and you cannot only form a pretty clear idea of his ability as a mechanic but also of his character, for to an observing person the slightest actions are an index to his character. Have you ever had a man approach you in this manner: "Say, boss, can you gimme a job? I'm an all-around good molder; heavy or light, bench or floor. Have just landed in town and would like to get to work." You put him to work and watch him for a while. Without doubt you will see him work away with his sleeves

dangling over his hands, and his floor will in a short time look like a mud road on a rainy day. His shovel will have half an inch of sand clinging to it, and rather than clean the blade he will plow through the sand heap using twice the necessary strength. His mold will be on top of six or eight inches of sand instead of down on the proper level of the foundry floor. The partings of the mold will look as if rats had been digging holes in them, and you may look for a goodly per cent. of his castings in the scrap heap. Then again yau are confronted with the man who believes that he can give you eminent satisfaction and is perfectly willing to have you judge his ability after giving him a fair trial. You may not see his rammer flying up and down like the piston rod of an upright engine at full speed; on the contrary, every stroke is gauged and is aimed at the right spot. He will clean up around his mold after "lifting off" and the edges and corners of his mold will be sharp and neat. It will hardly be necessary for you to see his castings before putting him down as a good man to "tie to."

Then there is the piece worker who will complain loudly when he is given an unaccustomed job. But when informed that owing to the absence of the man to whom the work is usually allotted he has been selected, he will be appeased and will work the harder and better, just to show you that he can.

If you catch one of the boys hitting another in the ear with the blacking bag, do not send him to the office for his money but tell him to go to the "gagger board and make two barrowfuls during the heat," see that he does so, and the next time he desires to have any sport he will take good care that the foreman is not handy. A boy may come to you with tears in his eyes, worked up and nervous over some misfortune to his mold, and will want to quit. Instead of letting him carry out his determination, after he cools off show him his mistake so that he will know better the next time and in the end he may turn out to be a valuable hand. So it is with the core-maker, cupola tender, chipper, and laborer. Of course you will find the "beat," and when you do lose no time in discharging him. In the end there is no iron-clad rule for governing a lot of men to secure the best results. For after all

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what are men but grown up children, all having peculiarities and eccentricities and, as Burns would say, "A mon's a mon for a' that." I repeat that the foundry is a good place for the study of human nature.

Mr. Fuller's remarks were applauded, after which a vote of thanks was tendered him and Dr. Moldenke.

At the business session preceding the reading of the papers the committee appointed at the previous meeting, consisting of Wm. Yagle, T. D. West, S. M. Rodgers and the chairman, Dr. Moldenke, presented resolutions in accordance with the request made at that meeting, upon the suggestions embodied in Dr. Kirk's letter. Chief among these was that the study of foundry practice be introduced as one of the courses of the curricula of the larger technical schools. The report which was adopted was as follows:

"We, the committee appointed by the Pittsburg Foundrymen's Association to consider the several suggestions contained in Dr. Kirk's letter to this association, report the following:

"Resolved, 1. That the foundry industry has arrived at a point where there is a demand for managers properly trained in the principles of scientific and commercial founding.

"2. That a representative body such as the American Foundrymen's Association be requested to draw the attention of the institutions of learning in this country to this fact, and urge them to take the necessary steps to supply the demand.

"3. That the Pittsburg Foundrymen's Association authorize the appointment of a committee of five, acting in conjunction with committees that may be appointed by other foundrymen's associations to memorialize the American Foundrymen's Association in accordance with the above resolutions."

On the new committee the chair reappointed the three members of the former committee, adding Secretary Zimmers and, in accordance with the request of the former committee, Dr. Moldenke will act as chairman, thus making the fifth member.

A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

AMERICAN MACHINIST.

Writing on "The Chemistry and Physics of Cast Iron," J. E. Johnson, Jr., of Pittsburg, says:

This is a subject which occupies a peculiar position, inasmuch as the consumers of pig iron for foundry and machine-building purposes, who have an urgent need to get correct information on it, have, as a general rule, very poor opportunities for doing so; while the competent furnaceman has the best of facilities for obtaining the information, but very little use for it, ecept incidentally.

The excuse of the present writer for saying anything upon the subject, if any is needed, is that he has spent portions of his life on both sides of this fence, and consequently obtained a view of both sides of the question. Moreover, a large portion of the blast-furnace part was spent under rather advantageous conditions for obtaining information, since the furnaces in question (those of the Longdale Iron Company, Longdale, Va.) were among the very first to make 'sandless pig iron," casting it, not on a casting machine, but into iron chills set in the cast house floor, these chills being practically "pig beds" of cast iron, with the shape of the pig modified to make it come out easily.

Not only was the iron sandless, but practically all the castings used around the works, of which there were a great many, were made on the premises and with iron taken direct from the furnace. The iron made was nearly all of the kind known as "basic open hearth," or briefly, "basic," and used, of course, for making steel in the basic open-hearth furnace. The specifications for this iron are that it shall not contain over 1 per cent of silicon or over .05 per cent of sulphur, and that it shall be sandless. The fracture is a matter of indifference, largely, and in general the iron is all right if the analysis is right, whether it be so hard that it breaks up into little pieces of its own accord, or so

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gray that it is covered with "kish" (graphite), though the preference of the users is usually for the softer iron.

A circumstance which threw a little more light on the subject was that occasionally part of a cast would be run into the chills and a part into ordinary sand beds. Analyses were made of every cast for sulphur and silicon, and by comparing the analysis of the iron and its fracture when run in chills, or sand, or both, with the character of the castings made from the same metal, much information was obtained.

One of the most evident facts was that the fracture was of very little or no use as a guide to the quality of the iron for foundry purposes. An iron made when a furnace is working right for "basic" may easily contain .04 per cent silicon and .02 per cent sulphur, and when run in large sand pigs and allowed to cool slowly will have a beautiful open fracture, good dark color, smooth face on the pig and graphite on its surface—all the indications of a first-class No. 2 iron; but run into chills it will be dead white over half the area of the pig, the white portion being on the bottom and sides where the iron is chilled most, and fairly open in the center.

That this iron was not ordinary "number 2" for the foundryman we once had a rather amusing illustration. We had a local customer who used our iron, in combination with others of the ordinary foundry brands made at other furnaces in the district, for making chilled minecar wheels. He had been getting for some time some No. 2 made in the days before we went on to basic, and of which we had a little stock that was reserved for him, and he liked it very well. But on one occasion, through a combination of circumstances, he was accidently shipped a car of this low-silicon "No. 2" which I have described, and the next mail after he had used the first heat of it, such a wail as we received! He had done just as he had always done, but his car wheels broke up in the flasks before they were shaken out, and he was in a terrible fix. We knew at once where the trouble lay, and shipped him another car from the old stock, but as this was getting low we had it analyzed to see what it really was (it having been made before the days of analyses of every cast), and whether

we should be able to supply him when this was gone. We found it to contain about 1.15 per cent silicon with normal sulphur, say .03 per cent. We sometimes made iron having just about that analysis when the furnaces "got over"; but it was nearly always cast in chills, of course, being intended for "basic." Knowing our customer personally, we asked him to let us ship him some of this iron, assuring him that it was the same as he had been getting except the fracture, which was closer. Knowing us, and that we would not abuse his confidence, he allowed us to do this, and has used the chill-cast silicon-off-basic ever since, with entire satisfaction.

There is no doubt whatever that any iron which would give the desired results in a casting, when re-melted from sand-cast pig, will do as well or better when remelted from chill-cast. A former correspondent shows that he is under a serious misapprehension when he says that no foundryman would venture to use chilled plow castings in the small ring requiring drilling of which he speaks, though the statement in itself is perfectly correct. This arises perhaps from the double use of the word "chill," which permits us to say that "any iron may be chilled, though not every iron will chill." Any iron which is cooled very rapidly in the mold is chilled in the literal sense, but only those irons which show a band of white running around the "chilled" part will, in the derived sense, "take a chill," or "chill," just in precisely the same way that any piece of steel may be quenched from a red heat, but by no means every piece will show the familiar effects of hardening.

This comparison furnishes the key to the whole subject, especially if taken in conjunction with Mr. West's statement that the chilled iron, when remelted, comes down softer than the sand-cast iron of the same composition poured from the same ladle, as should have been expected, for Mr. West had previously demonstrated past doubting that the chilled iron melted more easily than the sand-cast, and this being the case it is, of course, exposed for a less time to the action of the blast in the cupola, which burns out its silicon, and the coke, from which it absorbs sulphur, and escapes the sooner, therefore, from these two hard-

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ening tendencies. That hard iron melts easier than soft is, of course, no discovery of Mr. West's, having been known to furnacemen and founders alike for many years, but that, of two pieces of iron, one chilled and the other sand-cast, the chilled would melt the easier, he was the discoverer so far as the writer knows. This might have been expected on very different grounds, for the chemical change produced in cast iron by chilling is simply and solely that the percentage of combined carbon is increased and that of the graphite reduced by the same amount. Now we know that the melting point of iron rises very rapidly as the metalloids are removed, so that in mild steel, which is the purest form of iron we know commercially, it is enormously higher than that of cast iron, and it is reasonable to expect that increasing the metalloids, within limits, would lower the melting point.

As before stated, the key to the subject lies in considering cast iron and steel not as entirely separate and distinct, but as the same substance passing by infinitesimal gradations from the chemical and physical properties of one extreme to those of the other. The probable reason that this fact is not more widely realized than it is, is that both of the extreme conditions are "soft"—soft gray iron and soft or mild steel—while the connecting link between them is the hardest of tool steel at one end and the hardest of white iron at the other, with no sharp line separating them from one another.

There is no doubt that there could be made in a blast furnace, from the proper materials, an iron containing silicon 0.2, manganese 0.4, phosphorus 0.03, sulphur 0.03, combined carbon 2.75 per cent, graphitic, carbon, trace.

But excessively hard crucible steel may be made having precisely the same analysis, and both have practically the same properties. The crucible steel is so hard and brittle that it cannot be commercially rolled or hammered, and is of no value, as well as being extremely difficult to make, while the greatest care and effort, and probably several weeks or even months of trial, would be necessary to produce an iron with the composition given, in a blast furnace, and when produced it would be of little commer-

cial value; so that a material having this composition is seldom or never produced—never commercially—and we are not therefore familiar with it, and do not realize the fact, which it is impossible to emphasize too strongly in this connection, that it exists, or may exist, and constitutes a perfect link between cast iron and steel.

Since soft iron contains the most total carbon (about 4 per cent) and very mild steel the least (say, .06 per cent), while the intermediate stage, the very hard iron or steel just described, contains about the average of these two, roughly speaking, and is so much harder than either as not to resemble them in its properties, this may be thought to weaken or invalidate the above statement; but it does not, when properly considered, for while the total carbon is high in the cast iron, almost all of it is in the graphitic form and only a trace is combined.

If we say, 'Cast iron and steel are alloys of the chemical element, iron, with carbon, with a chemical and physical admixture of other compounds, and the hardness of the alloy depends, within commercial limits, upon the amount of the carbon in it, while its tenacity, ductility and other physical properties depend upon the other substances present, and upon the physical treatment it receives, and the variations produced by these are approximately the same in both," we shall have a blanket definition of the two substances which covers both quite fully and with substantial accuracy.

Too much stress can hardly be laid upon the two kinds of carbon in cast iron, the "combined" being chemically united or combined with the iron to form a chemical compound; the other, the graphitic, being merely interspersed among the grains or crystals of the iron. The most striking proof of this latter is that shown a few years ago, I have forgotten by whom, which consists in brushing with a steel-wire brush the fractured face of a pig of gray iron, one-half of which is protected from the action of the brush; the brushed half becomes perfectly white, like white iron, although the grain of course remains as before. The unbrushed half, of course, shows the contrast more plainly.

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Iron when hot has a far higher capacity for dissolving carbon and retaining it in combination than it has when cold. The graphitic carbon is probably all in solution at first, although this is not certain. But as the iron cools, if it cools slowly, the graphite is forced out and what is near the surface flies off into the air. It can be seen doing it at a blast-furnace cast when the iron is of the proper composition. The rest is retained, immeshed in the grains of the iron, and probably gives to gray cast iron whatever toughness and flexibility it possesses, separating the grains or crystals from continuous contact and lubricating their movements.

Thus hard cast iron, while much less flexible, is much more elastic than soft, as it should be, having much less graphitic carbon in it. The more slowly the iron cools the more graphite crystalizes out of it and the larger the crystals, so that comparatively hard iron, when cast into large masses and allowed to cool for several days, or longer, will show a grain which would put "No. 1 X" to the blush.

The chills alluded to early in this article were about six inches thick under the bottom of the "pig" and about five feet square, and when broken under the drop, after they were worn out, often showed very large crystals—much larger than those in pigs cast from the same iron, and the gates on them would show a first-class grain where broken off, even when the iron was quite hard. The accumulation of iron in the bottom of the furnace, which is sometimes formed during the blast when making this kind of iron, shows, when broken, enormous crystals, three-eighth inch or even half inch across in some parts.

The tendency to eject carbon and become softer in consequence, does not by any means stop when the iron is solid, nor until it is down to the lower limit of the red heat at least, and how much lower the writer will not undertake to say. When any casting was made from moderately hard iron which it was required to machine, it was always kept carefully covered up until dead cold, and this was known by experience to be very necessary. Some intentionally "chilled" pieces, when made of very hard iron, would "fly" of themselves from the cooling strains set

up, but could often be saved by keeping them hot as long as possible.

When the iron is cooled suddenly the carbon does not have time to separate out, and remains combined with the iron making it "white" instead of gray, because of the absence of the black graphite.

The similarity of this operation to that of hardening steel is, of course, obvious, the difference being that in the iron the carbon separates out physically and practically leaves the iron altogether, while in the steel it remains "combined"; but this difference is smaller than it seems, since microscopic analysis of steel in its hardened and unhardened conditions shows at least two forms of combined carbon, one of which exists when the steel is at a high temperature, and from which it gradually changes when the steel cools slowly, but which is retained when it is cooled quickly, and gives the steel its hardness. It is altogether probable that microscopic analysis of cast iron will show that it is the same form of carbon to which chilled white iron owes its hardness.

When cast iron contains comparatively little of other elements than carbon, its actions are comparatively simple and are approximately those previously outlined very briefly, but commonly it contains several other metalloids in appreciable quantities, and if this article is to be of practical use, as the writer hopes it will, some account of their individual and collective actions and effects is necessary.

Next to carbon in quantity and importance in nearly all commercial irons comes silicon. One of the principal effects of silicon is to prevent the iron from absorbing so much carbon, and especially from retaining it in solution at lower temperatures; so that as irons contain more silicon, they can contain less combined carbon, and are therefore less hard under all circumstances, or rather, more incapable of being hardened. The silicon is undoubtedly dissolved in the iron, and probably combined with it chemically, as is the carbon also at high temperatures when they are melted, but is forced out as the temperature falls. This is analogous to the action of double solutions. For instance, if

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calcium chloride and common salt be dissolved in hot water, and the solution evaporated down until concentrated and then allowed to cool, the salt will practically all be thrown down and the calcium chloride remain in solution. Silicon is supposed to increase fluidity, but it seems to the writer probable that its principal action is in forcing out the combined carbon and so raising the melting point by making the iron (in a sense) more like steel, and that the consequent necessity for increased heat-absorption to melt the iron gives it a greater heat-reserve and makes it more fluid in that way, rather than by any direct alloying action. Certain it is that iron very low in silicon, if made in a hot furnace, has a fluidity like that of quicksilver and far beyond that of the ordinary high-silicon iron.

The effect of silicon upon strength is complicated and depends upon many things. It is claimed to be a strengthener for small sections and up to a certain limit, but it is certain that above 2 per cent for ordinary work it is a weakener, the "silver-gray" irons and ferro silicon which contain from 4 to 10 per cent of it being utterly "rotten." One of the notable things about silicon is that in the amount of it present for a given grade, consists the chief difference between charcoal and coke iron, the charcoal iron containing vastly less than the coke. This explains why charcoal iron differs so materially from coke iron made in the same way in every respect, except the fuel. The charcoal iron having very little silicon, the amount of carbon dissolved in the iron is large, and a good deal of it goes into the combined form, while still sufficient is left to form some graphite and give toughness as well as strength.

Until very recent years furnacemen could not control their furnaces so closely as to make a coke iron low in silicon and sulphur at the same time, since the conditions for keeping both down are largely conflicting; so that when a tough, strong, chilling iron was needed, charcoal iron was largely used; but now a first-class furnaceman can make, with coke, an iron which will not differ appreciably in its chemical or physical characteristics from charcoal iron, and the latter is destined to a gradual decline, which it is now in fact undergoing, and has been for some years.

A very interesting suggestion was recently made to me by Mr. Macamson, chemist of the Chattanooga works of the Southern Pipe & Foundry Company, which was entirely new to me, though it may not be so to others. It was to the effect that the greater part of the silicon in coke iron might come from the ash of the coke, which is mainly silica, and that if this were so it would account for the low silicon contents of charcoal iron. This suggestion has features which bear very close examination well. We know that the most intense heat of the furnace is required for the reduction of silica to silicon, and that this is only to be found immediately at or near the level of the tuyeres, while the silica of the ore and of the burned portion of the coke, having been in intimate contact with the lime since they left the top of the furnace, or soon after, has very probably been taken up by the lime and converted into slag, from which it would not be likely to be reduced, while the portion of the coke which comes down to the tuyeres still unburnt exposes its contained silica under the most favorable circumstances for being reduced, and in position to be washed off the coke and absorbed by the melted iron in its descent, gradually, as the successive portions of silica are exposed by the burning away of the coke.

It is immediately in this region also that the cyanides are known to exist which are held by Mr. Bell to be probably concerned in the final reductions. It is a fact also that a much greater proportional quantity of coke is used for making high-silicon than for low-silicon iron, which points strongly the same way. Sulphur is, quantity for quantity, the worst element occurring in cast iron. It is in itself a hardener and probably acts on the carbon to keep it in the combined state as well. It is commonly the result of a "cold furnace," since heat not only tends to drive it off, but the investigations of a French scientist, within a few years, shows that high-sulphur iron melts more readily than low-sulphur iron, which would be expected if the sulphur acted to throw the carbon into the combined state, so that if the furnace gets cold, the effect is double; the iron absorbs sulphur, which enables it to melt at the low temperature. Sulphur increases shrinkage, and undoubtedly also causes blow-holes, and except

for the trifling fact that it increases strength, is a detriment in every way.

Sulphur comes almost entirely from the coke. Some ores which carry much sulphur require roasting before going into the furnace, to drive it off; but by far the greater part of the ores now used are free from it to a great extent. Good coke, however, always contains somewhere from .5 to 1 per cent, and bad may contain up to 3 per cent, or more. The almost complete freedom of charcoal from this element is one of the reasons which make it easy to produce with that fuel a tough, strong iron, for the conditions for the control of sulphur and for that of silicon are largely antagonistic, and being almost wholly rid of both at the critical point, assuming Mr. Macamson's suggestion to be right, it was easy, even in the days before chemists, to produce an iron which was largely an alloy of iron and carbon, pure and simple, and correspondingly strong and tough, especially where the phosphorus happened to be low.

The danger from sulphur is not over when the iron is made, as far as the foundryman is concerned, for in remelting the iron with coke it is certain to absorb some sulphur even with good coke, and may take up a ruinous amount from bad, and when a founder begins to have trouble from hard castings, blow-ho'es on the top surface, and heavy shrinkage, he had better have an analysis of his coke made before he goes after the furnaceman, "hunting trouble."

Phosphorus is an element which is probably more condemned than it deserves in cast iron, although in steel it is fully as objectionable as it is commonly considered to be. Its effect is the same in both, and may be best expressed by saying that it makes the metal treacherous. In steel which requires to be as nearly absolutely reliable and certain in its behavior as it can be made, this is the worst quality possible; but in cast iron, being inherently and necessarily an uncertain, not to say treacherous, metal any way, the slight addition to this quality caused by phosphorus in moderate quantity may be more than offset by its other effects. One of these undoubtedly is to increase the fluidity, and another

is to decrease shrinkage. Phosphorus is also a strengthener up to about .5 per cent, as shown by recent tests.

Phosphorus has the effect in chilling iron of causing the white portion to be separated from the gray of the casting by a distinct line, instead of the two being interlaced and changing gradually over a considerable width; and as this last is a necessary condition for a strong, reliable chill, phosphorus to the extent of more than about .2 or .3 per cent is not to be recommended in a chilling iron, especially a car-wheel iron. This is simply another case in which it tends to make the metal treacherous, and as car-wheels receive the severest treatment of almost any form of cast iron, phosphorus is not allowable in them.

Manganese is an element which is probably blamed sometimes for faults which it does not possess. It is undoubtedly a hardener in either cast iron or steel, and if present to the extent of 2 per cent, or more, may work serious injury; but ordinarily, when not in excess of 1 per cent, it is more of a benefit than an injury, since it has a strong affinity for sulphur and tends to absorb it and slag it off when being remelted. The makers of basic open-hearth steel are very partial to it and desire to have it in the iron to the extent of 1 per cent, when possible, for this reason; and there is no doubt whatever that the same action takes place in the cupola.

These are the elements upon whose presence in the iron as poured, and the physical treatment it receives at and after casting, the character of the iron depends wholly, irrespective of the previous state it was in; whether chilled or soft, open-grained or close.

I have given here a very brief review of the actions of these elements. Those who desire to obtain more detailed knowledge of the subject would do well to consult a paper written by Mr. Guy R. Johnson and read about three years ago before the Foundrymen's Association at Philadelphia. In it are given analyses and tests of many hundreds of irons containing different proportions of the different metalloids and grouped in different ways. It was, so far as the writer knows, the most complete statement of ascertained facts yet published which concerned itself

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with practical results mainly. In this the effects of the different elements were stated and illustratd by tables giving the results of a vast number of experiments, and the compound effects due to the variations of two or more elements simultaneously were explained at some length, the whole being undertaken with the view of solving practical foundry problems.

Before leaving this very interesting subject I wish to offer a few suggestions to foundrymen, which I hope will help forward foundry practice to some minute degree if followed out.

In the first place, while it ought not to be necessary to say it, the most essential point is to dismiss utterly the old notion, inculcated so thoroughly by the old regime in the foundry world, that everything is mysterious about the business and that the results desired can only be obtained by following traditions long established. The modern proposition to replace this is that the behavior of the iron in all respects depends upon its chemical composition and the way in which it is treated at and after pouring, the chemical composition being understood to be that as poured, not as charged into the cupola. There is generally a very perceptible difference between these two. Some silicon is always burnt out, depending on the method of operating the cupola and the quantity of silicon originally present. With good cupola practice and iron containing about 2.50 per cent, about 0.2 per cent is burned out, and by slow melting, bad arrangement of the tuyeres, etc., this may be increased materially.

Some sulphur is nearly always absorbed, as before stated, the amount depending upon the quantity contained in the coke, the intensity of the heat of the cupola, the lime used and other factors, those mentioned being the most important and named in the order of their importance. This is a matter which varies largely, but on the average it is probably safe to say that to have an absorption of less than .025 per cent is good practice, and it is on this account more than any other that remelted iron is disliked and the use of sprues and gates condemned where "dead soft" work is desired.

The manganese is apt to be considerably lower if much is present, and this is a good thing, for it means that it has largely

gone in the removal of sulphur, and both being hardeners, the effect is undoubtedly beneficial.

The reduction of the quantity of manganese depends upon various factors, and the writer does not feel able to give any figures for it that would be even an approximation in the general average case, but as small quantities of manganese do not, of themselves, affect the character of the iron very greatly, this variation is not so important as the others.

The variation of the phosphorus is, in good general practice, negligible. None will go out, and with decent coke very little will enter the iron. The amount of the variation in total carbon is very variable and depends largely upon the method of melting. Some carbon is always burnt out in melting pig iron, and it is probably safe to say that it is always the graphitic which goes, since, owing to the decrease of silicon and increase of sulphur the combined carbon always tends to increase. Moreover, the graphite is blown away by the blast during melting.

When the iron is melted in the air furnace a large quantity of the carbon is burnt out, and also more of the silicon than in the cupola, with the result that the iron is able to hold most of the carbon in the combined state, so that castings from metal so melted are strong, but not at all flexible. By annealing these, however, with oxide of iron at a high heat the oxide absorbs still more of the carbon from the exterior surface of the casting, and it is reduced to practically wrought iron on the outside.

In general cupola practice, however, probably not over .1 to .2 per cent of carbon is burnt out.

If, now, a foundryman has a mixture which gives him exactly the results he wishes in his castings, and wishes, for any reason, to get the same results with a different combination of irons, he has only to have an analysis made of the casting which suits him, modify it along the lines indicated to find what the analysis of the mixture previous to melting was, and by simple proportion figure out from the analyses of any given series of irons a mixture that will duplicate it, and he will get the result in his castings every time, unless some miscalculation has been made or other conditions altered.

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The analyses of irons may always be obtained from the agents or the parties making them, and in this connection I would like to state that founders make a great mistake in not regarding the furnace men as their friends rather than their enemies. Most of them will be found willing to help in many ways to the results the foundryman desires, and the idea that they will shove off anything on the customer he will take is all wrong. If foundrymen would go, or write, to them when difficulties arise it would be of benefit to both parties in many cases.

One or two points upon current notions in the business are so practical that I wish to insert them here, as this is intended as a strictly practical article.

One is the idea that the entire virtue of an iron is gaged by the percentage of silicon it contains; the other is that phosphorus is always necessarily an evil, and manganese, to a less extent, the same. The percentage of silicon which exercises any influence on the chilling properties of an iron is soon passed; probably at 1.50 per cent, certainly at 2 per cent, and the influence of the silicon as a hardener by itself, as distinguished from its action on the carbon, begins to be felt increasingly after this point is passed. It is doubtful, also, whether it increases fluidity appreciably after this, while it undoubtedly becomes a "weakener" as the percentage rises beyond this point.

Moreover, silicon is the great dirt producer. Some of it is always burnt out in the cupola; as stated, the oxide of silicon, or silica, so formed is seldom perfectly slagged off, and comes out mixed with iron, from which it separates when given time to rise to the surface, with the results that foundrymen know so well.

Where a large quantity of scrap is to be carried it is considered necessary to have high silicon in the iron, but as the scrap, unless obviously hard, probably contains a fair amount of silicon, it is not necessary to make up any great deficiency, and the use of high silicon has probably arisen from the fact that the scrap is undoubtedly harder, but far more from high sulphur than from low silicon, and the high silicon of the new iron may to some extent act as a neutralizer of the sulphur, but it does not have this effect to more than a limited degree.

Where ordinary good scrap is used and the general run of machinery castings made, it will, the writer feels sure, be better to use an iron of high manganese, 1 to 2 per cent, according to the percentage of scrap to be carried, with only moderately high silicon. This will remove the sulphur or keep it down, and the result desired will be obtained without the evils of high silicon.

Phosphorus is admittedly an element productive of some uncertainty, but is not invariably a weakener; on the contrary, at least for small and medium size castings, not chilled, it is a strengthener up to .5 per cent, and its influence on fluidity is enormous. An iron containing silicon, 1 per cent; phosphorus, 1 per cent, will be vastly more fluid and make far sounder castings than one containing silicon, 3 per cent, phosphorus, .2 per cent, and will have less shrinkage; though 1 per cent phosphorus is not recommended by the writer.

In a general way it is probable that the average foundryman strives to obtain for the general run of work an iron which analyzes roughly silicon, 2.70 per cent; sulphur, .05 per cent; phosphorus, .2 per cent; manganese, .25 per cent; combined carbon, .15 per cent; graphite carbon, 3 per cent.

If instead he would aim for one containing silicon, 1.40 per cent; sulphur, .03 per cent; phosphorus, .5 per cent; manganese, .6 per cent; combined carbon, .4 per cent; graphite carbon, 2.5 per cent, it is the profound conviction of the writer that he would get an iron stronger, equally flexible, and more elastic, more fluid, as easily machined and much easier on the tools, cleaner, indefinitely more steam tight, and with less shrinkage.

This article has already far outgrown its intended limit; and no more will be said in favor of this contention now; but should any reader do me the honor to ask for proof or illustration I will endeavor to supply.

L. C. Jewett writes as follows in an article on "Making Follow Boards":

Among the many conveniences required by the molder, particularly the bench molder, to economize and expedite his labors, follow or match boards perform an important part, and especially

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so in these days with solid patterns with few, if any, loose parts. Patterns, however crooked the lines of the joint may be, can be molded without a follow board, and where there are but two or three castings required from the pattern, follow boards would not be economy, as they require both time and material. Large work of any kind made on side or crane floors, or bedded in flasks or floor-pit, large gears above 18 inches in diameter, spur or bevel, do not require a follow board, and on any pattern that is bedded in, it could not be used.

Follow boards are made of various substances, depending on the service required, as well as the nicety and the weight. The latter becomes a noticeable matter where the board is used many times in a day. The first operation in making a follow board is to place the pattern in the nowel part of the flask and in the position wanted, right hight, desired slant, etc. Make a joint where a joint line is required on the pattern, using the same care as if a cope was to be rammed upon it. Have the joint of even firmness. In many cases it is a good practice to rap and withdraw the pattern to see if the joint is all right. When repairs are made, if required, return the pattern to its place. If it is desired to make the follow board of plaster of Paris, it will be necessary to coat the pattern with some oily or greasy substance where contact with the liquid plaster is to occur. Crude petroleum, strong soapsuds, vaseline thinned with kerosene, and applied with brush or fingers, are among the best articles used. Give the nowel joint a dusting of plumbago.

The carpenter should make a frame the same size as the flask, of 2 or 1½-inch stock and as shallow as possible. Where necessary, projections of the pattern could be let into or through the bottom board. The frame should be attached to the bottom board with nails projecting inward from the board and edges of the frame, to hold the plaster in place when it becomes dry. In many cases parts of the frame can be blocked off or filled with wood to lessen the weight. Holes two inches in diameter should be bored through the bottom board for pouring the liquid plaster. Some boards, where the top is level, are poured with the bottom board off. The board with frame attached is placed on the nowel

and clamped or weighted, the latter way being less liable to warp frame or nowel. See that the joint and all openings are tightly calked with wet sand. Place good large cups or sand runners around the pouring holes, and then prepare the plaster to pour.

To add water to the plaster is not as good as to add the plaster to the water. Get the water in a circular motion before adding the plaster; keep stirring and keep the plaster going into the water (do not have lumps), until it comes to the consistency of thick cream, and pour at once. Stay by it when filled, with a little more plaster to keep the heads of the openings up. As the water percolates through the sand, the pouring hole or holes will shrink down, hence the touching up. The addition of salt to the water renders the plaster firmer when dry. Thirty to sixty minutes, according to the character of the follow board, should pass, after pouring, before rolling over. Remove the nowel and the sand from the plaster joint. Rap the pattern gently and remove. Don't wait too long, as plaster shrinkks as it dries, requiring considerable cutting and relieving to have the pattern go easily into place. Do not wash with water and brush, but brush when dry.

Blocks of plaster of Paris are used to form the joint between oval arms in patterns of wheels, gears, pulleys, etc., or to place under parts and projections of patterns to bring the joint in proper place and shape for the cope to be rammed upon.

For litharge-sand follow boards, first mix litharge with boiled linseed oil—two or three tablespoonfuls of litharge to a pint of oil. Oil may be used without the litharge, but it gets dry and firm in less time with the litharge in it. Take dry sand (new molding sand is preferable, but fine burnt core sand works well or burnt molding sand), dampen or temper the sand with the boiled oil to a good damp condition. Riddle this tempered sand through a No. 4 or 6 sieve, to thoroughly mix and incorporate; be sure and clean the sieve while it is still damp. The nowel having been prepared the same as for a plaster board, with the exception of oiling the pattern, place the frame upon the nowel joint and proceed to tuck in thoroughly into every portion of the pattern the prepared oil-tempered sand. With fingers and hand

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put on a surplus of the mixture, finishing with a gentle but thorough ramming with the butt of a hand rammer. Strike off, and put on the bottom board, thoroughly rubbed on, and securely nailed to the frame. Turn over nowel and follow board, removing nowel and sand. If it is required to be secured with nails to the board this is best done before the pattern is withdrawn. When finished place on top or in the bottom of the core oven, where it will not get too much heat. It will require from eight to twelve hours to be fit for use.

Litharge follow boards are expensive, but are the best known, and if to be much used are certainly the cheapest, inasmuch as they are not liable to shrink, swell or crack, and if the joint line is altered in any way is easily performed. Follow boards 36x36x1 inches have been made of this material by nailing the oiled sand with nails 4 inches apart to the bottom board. Follow boards can be made thinner with oil, and consequently lighter, being more durable than of plaster. To coat plaster or oil follow boards with black shellac is good practice.

Wooden follow boards are often used, and frequently a hole or slot in the board is all that is required, but where the joint line is irregular wooden boards are too expensive, besides being subject to atmospheric conditions that are annoying. Where there are but few castings to be made from a pattern the molder will quickly make a follow board from molding sand. He should, and usually does, have frames of various depths, for either upsetting flasks or for quickly making molding sand follow boards for temporary use. It may be in place to say that the follow board is used to place therein the pattern upon which the nowel is rammed, and when the nowel is turned over and the board removed the joint is wholly or partially ready for the cope to be rammed upon it after the parting sand is on.

IRON TRADE REVIEW.

Erastus C. Wheeler contributes to this journal the following paper relating to the "Employer and Employe":

One of the first recorded instances of a misunderstanding occurring between employer and employe comes down to us

from Biblical history in the parable of the vineyard. The men who had toiled the whole day received no more pay than those whose labor was but for an hour. The master of the vineyard made the remark that is characteristic of many employers of the present day. It may be argued, and justly too, that both parties in this historic unpleasantness were justified in their statements. It has always been an employer's argument that it is his indisputable privilege to do with his own what he wishes; but the contemporary statements offered by the supporters of labor organizations, contains just a suspicion of socialism, by advancing the argument that the employer's capital represents the savings upon the laborer's hire, and the distribution of the same should be equal among all men performing the same class of work. The above statement, while having a distinctly attractive side, leaves after some little thought a somewhat disagreeable taste in one's mouth. If all men performing some one specified class of work were endowed by nature with equal brains, then the employer would have no difficulty in apportioning his money share and share alike. The employer, however, contends that men are not born equal by any means, and while recognizing one man's best endeavors, the next man's best may be better than the first man's, and therefore the latter is capable of performing the same amount of labor in less time, and hence is the more valuable man.

It is in following up these statements from the employe's standpoint that in any concern whose output is manufactured by a piece-work system, the better man will, by using his superior intelligence, gradually draw away from his companion whose capabilities are not of such a high order. But labor dictates that it must protect the latter and those who are dependent upon him for support, and therefore has tried to arrange for a uniform rate of wages. Both sides present admirable arguments, and there seems to be underlying each a strong desire to follow out the principles of the golden rule. Then why, we may ask, are there so many painful and distressing occurrences; which not only mar the face of labor, but prejudice its best friend, the employer. Human temperament is a variable quantity. There are some men who will never "lose" themselves during a lifetime, and who will

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always wait until a storm has passed, before taking any initiative, which might be construed as direct animosity. Again there are those who will "fire up" quickly and steam out, often before the real cause of a grievance is clear in their minds. These latter commit a serious breach of their moral obligation to an employer, while imagining that it is a lack of confidence in them which has prompted a management to introduce or alter something in their daily routine or wages. By this hasty action other employes are involved, whether their sympathy has been touched or not. Often the cause is so far removed from some departments, that the dissatisfaction following these sympathy movements has proved a mighty factor working toward the dissolution of organized labor.

In his endeavor to justify a radical action, the employe often carries his grievance so far that an element of the ridiculous enters into his arguments which robs them of their greatest force. It is the history of all business and social enterprises that the strong will ever dominate. Albeit the cause of the weaker may be just and honorable. Here at the closing of the nineteenth century we find for the first time in history, an agreement between employer and employe for the arbitration of their respective grievances, and pledging themselves alike to abide by the decisions of the arbitrators. The far-reaching import of this agreement and its certain conciliatory influences have not as yet begun to be appreciated. There is no country on this earth where the employe may come in as close touch, and have as much respect shown him by his employer, as in the United States. There are many manufacturers whose employes reach into the thousands who may go about their shops and personally greet every individual worker. If this is not in itself a token of honest appreciation we fail in power of comprehension. This feature has been brought about in a great measure by the environment of employer and employe, the result of following the precepts laid down by the founders of this government, who stood for the glorification of all honest manhood. It is the acknowledgment of obligations incumbent upon both that has moved capital and labor to arrive at this worthy solution of a vexatious problem.

The attitude of labor has changed wonderfully during the past few years, and its position to-day is no doubt the result of careful study on the part of its leaders, of the motives and necessities, which lead capital to inaugurate methods sometimes defensive, though always with some mutual benefit in view. Thus the introductional of any labor-saving device which will lessen the laborer's burden is being accepted to-day by organized labor as a certain preventive of the old time discontent which was always fermenting in industries where heat, smoke and foul air were ever present. It was the effect of these conditions upon human nature, that caused many a community to undergo the terrors of a strike.

The manager in engaging labor is under the same obligations for a faithful performance of his part as is the workman, for he has in exchange for a man's endeavors in his behalf guaranteed a ratio of remuneration. When either fails in this agreement and a question arises as to whose liability is involved, it is then the plan and scope of the arbitration proviso to adjust the difficulty. The employer's attitude toward his men should be one of personal encouragement, which can assert itself in both words and cash. There should not be any attempt to belittle or depreciate any man's endeavors in business or society. Every individual in possession of reasoning faculties has in his make-up a certain amount of pride, which when touched by a careless word, sarcasm, or the enforcement of some order, which he believes is unjust, tending toward keeping him in his "place," will naturally enough be offended. It is in keeping with the general evolution and with the order of human progress that large opportunity is for the few, and those who are enjoying the benefits of higher positions should not be unmindful of this fact. In all branches of the industrial arts will be found men whose brain is as capable of as large a development as that of the foreman immediately over them. When the history of any successful man in industry or commercial life is known it is found that he either rose by his own merits or traces his standing to some one whose start in life was at the bottom. Equality is an impossible condition either in business or society. With it there would be no interest or de-

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sire, and the wheels of progress would gradually cease to revolve.

It should be the one aim of an employer to maintain his men in a satisfied and contented relation and not allow himself or others to let a personal feeling endanger any man's position. If an employe proves a detriment to the business, he should be allowed to make his exit as quietly as possible. The employe on the other hand who enters an establishment and is willing to work for the wages offered, binds himself with a contract of moral obligation to keep his end up. When he finds in that shop the men already in service are governed by certain rules, to which he cannot subscribe, and still continues to draw his wages, he is guilty of a wrong, which if perpetrated by the employer would cause trouble. If you are not with your concern in spirit, you will be against it in some word or act or omission. The employe must respect to be respected in return. If he allows any feeling of false equality to pervade his manner toward foreman and employer, he is in the wrong. Outside of the shop, the man is as good as the master. Inside, the latter's authority is to be respected; yet it may be enforced in such a manner that it need never impress the workman as being hard; for if they are properly placed, and tact is in command, the men may be guided at will, without being aware of the influence directly exerted.

It is not compatible with good judgment to expect employes to report the seeming inefficiencies of fellow-workers, though when men are performing work improperly, purely through ignorance, and are capable of doing it correctly, a word from a co-employe should never be misconstrued. There are not many avenues open through which the co-operation of employes may be successfully elicited, without meeting the prejudices of some one in a concern. An employe may have a good idea concerning the production of material. He does not always care to divulge it to a middle man, and hence the thing lies dormant or dies altogether. If, however, he may reach the management without endangering his position with a foreman, and there receive some proper encouragement, the opportunity to broaden his possibilities appeals at once to his sense of originality. In order that a concern may avail itself of its employes' best thoughts, and enable

the latter to vary the dull routine of every-day life by working up schemes through daily contact with and study of their machines and the method of doing work, a company should recognize these efforts with a reward. One of the most successful concerns in the country is operating a model plant on these lines, and the return attending the system is now a matter of international interest. It is not too much to say that this plan has a direct bearing upon the feelings and temperaments of the employes, for it has a tendency to lessen the distance between the man and the master, and this is not to be depreciated.

Differences between capital and labor are not always because the rate of wages paid was unsatisfactory (although such was the given cause), but often because down in the hearts of employes has been that omnipresent desire to "get even" for what has appeared to them at times as mere toleration. If it were possible for employer and employe to exchange places and see each other, as they had formerly regarded each, the sensations of both would be very interesting indeed, and would of necessity do much toward the removal of their respective grievances. As human nature cannot adjust itself to these conditions, the arbitration board should be given all the more credit, presenting as it does the only possible and sensible solution of the problem.

There is one individual who stands between the employer and employe, and whose importance in the general complexion of a large works is often underestimated. The foreman is the proxy of the management in all dealings with the men, and upon his personality depends the harmonious conduct of any business. The commands and desires of a management are given literally, and this foreman must be broad and tactful enough to comprehend that such orders are to be translated according to the immediate situation, he may find in his shop. A foreman's manner toward his men is but the reflection of the manager's attitude toward him, and it is an exceptional man who is not susceptible to this influence. Moderation should be preached on every occasion, remembering that this foreman is the representative of both employer and employe. If he is vindictive and abuses the men, they will put up with it for a while, but they never forget. You

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cannot touch the past, but it can touch you when you are least prepared to defend yourself. Many instances are on record in which a lack of preception has caused untold friction and loss.

THE FOUNDRY.

Writing of "Shot Iron and Hard Spots in Castings," Edward Kirk says:

There are numerous small particles of molten iron which fall from the cupola spout to the floor when tapping out, stopping up and changing ladles. Iron is spilled from ladles in the gangway by careless molders, when carrying them; small particles are frequently spilled on the top of molds when pouring, and many small particles fall from the cupola when the bottom is dropped.

This iron when collected is designated in different foundries as shot iron, gangway scrap, foundry scrap, cupola scrap, tumbling barrel scrap, etc. In describing it, we shall designate it by its more common name, shot iron, and include in it all very small scrap from a foundry, such as shot, fins, vents, shells from runners, ladle sculls etc.

Shot iron is collected from the dump when cold by breaking it up and carefully picking it over to recover the iron. In this way of recovering the iron, many or all the smaller particles are left. In foundries in which tumbling barrels are used, the entire dump is generally broken up and thrown into the barrels, with castings to be cleaned, or into a tumbling barrel kept for tumbling the dump. When put in with the castings, many small particles of iron are lost by passing through the large holes in the staves, or cracks between them. When a barrel is kept for the dump the openings are generally made smaller for the escape of the dirt and cinder, and more iron is recovered.

Shot and other light scrap from the top of flasks is collected upon a shovel and thrown into the gangway or dumped into the sand heap by careless molders and recovered when riddling sand for a mold and thrown out. Shot from about the cupola spout and gangways is collected by scraping or sweeping up the floors and riddling this or putting

it in the tumbling barrel with the dump. When riddled, a number two riddle is generally used, and all the small particles of iron are lost that are recovered, when the refuse is thrown into a close tumbling barrel.

A machine has been invented and is now in use in some foundries for recovering every particle of iron from foundry refuse.

The dump and other refuse is first broken up and cleaned in the tumbling barrels and the smaller particles of iron, escaping from the barrels, are recovered by passing the refuse from under the barrels through a machine consisting of an ingenuous combination of vibrating screen and fan, for extracting all shot and other small iron from the refuse.

A barrow full of refuse will pass through the separator in three or four minutes. All the iron being deposited in a box provided for it and all other material thrown to the rear of the machine. We have seen this machine in operation, and it does its work to perfection. Founders who believe in saving every particle or iron, can do so by putting in one of them.

Some founders endeavor to recover every particle of iron from foundry refuse, others only recover the larger pieces, and permit the cupola dump and also gangway cleanings to be thrown in the dump, without first recovering the small iron.

Let us see which of them is best off in the end.

Shot iron from the dump is hardened to some extent by rapid cooling of the dump by water, and is annealed by slow cooling and softened to a considerable extent.

To prevent hardening this iron, some foundries only permit a few buckets of water to be thrown on to deaden the surface, and permit the dump to cool slowly.

Shot from the gangways is hardened to a perceptible degree by sudden cooling in the open air, and partakes of the characteristic of the iron from which it was made. That from very soft iron is soft but hardened to some degree. That from an iron inclined to run hard is white all the way through, or shows a white outer edge. By noticing the character of iron in shot on the top of

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molds, an accurate idea of the quality of iron in the castings may be formed, especially in light castings.

To restore gangway shot, vents, etc., to their former condition, they are sometimes, after being cleaned, thrown on top of the cupola dump and permitted to anneal over night, then thrown in the tumbling barrels and recovered with the dump scrap. It is doubtful if this restores the iron to its former condition, although it is softened to a perceptible degree when the dump is of a sufficient size to retain its heat for any length of time.

This was the common practice, some years ago, in foundries making fine castings from charcoal iron, costing from forty to fifty dollars per ton.

Founders have always been troubled with hard iron to a greater or less extent, and among the numerous causes assigned for it, is that of shot iron hardening other irons when melted with it.

To prevent this iron hardening other irons, various plans have been devised for melting it; among them the melting of shot at the end of a heat, or in a heat by itself, and run into pig to be melted with other iron in the the regular heats.

A device was patented a number of years ago for melting shot, consisting of a cast iron pot or tube with a device for tightly closing the end with a cast cover to exclude the blast of the cupola. It has also been melted in tight wooden boxes, open pots, and enclosed in iron by placing it in pig molds and pouring molten iron upon it, in such a way as to inclose or imbed it in the pig.

It has been found that the quality of shot iron is not improved by melting it at the end of a heat, or in a separate heat and running it into pig, but is deteriorated by so doing, and does not mix with other irons as well after being run into pig as when in its original state.

This is more especially the case when the iron is melted in a separate heat, for the reason that some time, and perhaps months, are required to collect a sufficient quantity of it for a heat. During this time the iron becomes heavily coated with rust, which greatly deteriorates its quality as well as the quantity of iron in

the shot before it is melted, and produces an inferior quality of iron to that obtained from a new shot free from rust.

The melting of an entire heat of shot iron is a very unsatisfactory operation. The fine iron packs so close that the blast cannot penetrate it in any great volume, and is thrown back upon the blower. In case of a forced or positive blast, the belts are either thrown off or the blast finds a few openings through which the greater part escapes, and in either case the melting is slow and many small particles of iron become imbedded in the cinder and slag around the cupola and have to be recovered from the dump.

It might be as well to say something about the recovery of iron from foundry dumps here as elsewhere, as this iron comes under the head of shot iron, as we have classified shot iron in describing it.

Founders who come into possession of foundry plants that have been run by others for a number of years, frequently find in the foundry a dump a considerable quantity of iron, which may have been placed there by careless workmen, or by the old management, for unknown reasons. The new management frequently undertakes to recover the iron, under the impression that its loss was due to the extravagance or carelessness of the former management, which is not always the case.

Jesse Star, when running the Camden Iron Works, one of the largest pipe foundries in this country at the time, threw the cupola dump and gangway cleanings in the foundry dump, after recovering only the larger pieces of iron.

When a new management took charge of these works, they discovered this supposed extravagance, and a gang of men were put to work to recover the iron, many tons of which were taken from the dump, melted and run into foundry pig, for future use in the regular heats. This iron was soft iron suitable for pipe work, when consigned to the dump; but had lain in the dump for a number of years, and became oxidized or heavily coated with rust, and when melted and run into pig was very hard. The pig, when melted with other pig, would not mix with other irons, to make a soft or homogeneous casting. This was probably due

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to a change effected in the iron by oxidization, while in the dump.

After numerous attempts to use the iron in various ways, resulting in the loss of many castings, it was piled in the foundry yard, where it has remained for probably twenty years. A fair sample of foundry pig, the iron was only fit for weights, and was not worth half it cost to recover it; even with pig iron at a high price.

A stove foundry making plate from cold blast charcoal iron, many years ago, found the plate to run hard, when the gates and sprues were remelted with pig, and threw them with all other small scrap into the dump. An attempt was made, after it had lain there for many years, to recover this high-priced iron from the dump, but it was found after a considerable amount had been recovered and run into pig, that it was not worth the cost of recovering it. Other instances might be cited of the recovery of dump iron, but these are probably sufficient.

The experience of numerous foundries we have met show that it does not pay to recover iron from a dump, if it has lain there any length of time, no matter how great the quantity of iron in the dump.

The device patented for melting shot in iron pots, consisted of a pot or tube with one end closed and cast in a three-part flask, that a groove and a number of small lugs might be cast on the open end for holding the cover in place. The cover is cast with a number of small notches for passing the lugs, and when dropped into place in the groove in the end of the pot, and slightly turned, is securely held in place by the lugs, and may be looted with clay or other material, to exclude air from the pot and its contents.

These tubes were made to hold from 50 to 100 pounds of shot, and when filled and looted were charged into the cupola with other iron, care being taken not to break them in charging.

These tubes or pots excluded the blast from the shot until the pot melted and its contents were heated almost to the melting point. But is was found that the pots did not improve the quality of iron melted from the shot to a sufficient extent to justify the

expense of making, filling and looting them, and their use has long since been abandoned.

When melted in wooden boxes, the boxes are generally made of one-inch hemlock or other cheap boards, securely nailed to hold the small iron together, and from fifty to one hundred pounds of shot are placed in a box and the cover nailed on. These boxes are generally charged on top of the pig, and care taken not to break them, when charging scrap or other iron. The boxes do not burn in a cupola when charged with other stock, until they settle into the melting zone, where they are consumed, leaving the shot in a compact mass to be melted. This way of melting shot iron was supposed, for a number of years, to give excellent results in melting it, but this has been proven to be a fallacy, and the boxing of shot has generally been abandoned.

The enclosing of shot iron in pigs by pouring molten iron around it, is a very difficult and unsatisfactory operation.

When shot is placed in sand molds, many small particles are lost in the sand, and the sand in a short time becomes a scrap bed. When placed in an iron pig mold, in any quantities, the molten iron, when poured upon the shot, does not penetrate the mass to any extent, and the only shot that adheres to the pig, when cold, are those on the surface, and many of these drop off in handling the pig. The only way to get this iron thoroughly enclosed in a pig is to place it in molten iron in the pig mold. This is a dangerous process, as damp, cold, or rusted iron causes molten iron to explode, and it is almost impossible to keep this small iron entirely free from dampness and rust in a foundry. This way of preparing shot iron for melting is generally abandoned after a few trials.

From shot iron we may obtain, when remelted three distinct grades of iron, which for convenience in describing we shall classify as Nos. 1, 2 and 3 foundry pig, which are not to be confounded with foundry irons of these grades.

These three grades are made from exactly the same iron and may be cast in the same heat. But two of them are not produced by changes effected in the iron in the cupola, nor by the size of

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shot or manner of cooling, but are produced by a change effected by oxidization, or rusting of the iron after it is cast.

In demonstrating the existence of these three grades of iron, numerous experiments were made in melting shot iron; to determine the cause of hard and uneven iron in castings, when a soft iron had been placed in the cupola.

In making these experiments or tests, the shot was placed in closed wooden boxes, and melted alone in a small cupola, that the results might not be changed by the mixing of iron from the shot with other iron that might have lodged in the cupola, if melted at the end of a heat of other iron.

A few boxes of new clean shot from the tumbling barrels were first melted and run into pig. The pig when broken in various places showed a small crystal of an even size throughout the fracture, and in the different fractures. The iron filed and drilled freely in the pig, but was much harder than the iron from which the shot was made, and when run into a plate a half inch thick, which was done from the same ladle the pig was cast, was too hard to drill freely. This iron was afterwards found to be the softest iron that could be obtained from shot iron, and was designated No. 1 foundry pig.

A promiscuous lot of shot that had lain for some time and was heavily coated with rust was next boxed and melted in the same way. This produced a pig which, when broken in various places, showed a very uneven crystalization in the fracture. In some spots or places the iron was almost white, and in others showed a small open crystal. The half-inch plate cast from this iron showed an uneven fracture, like the pig, and was too hard to be drilled in any part.

In this test a spotted, uneven iron was produced in the pig, and to determine the iron that caused the hard spots, the rusted pile of shot was carefully sorted and all the very small or fine shot placed in boxes by themselves and the large shot or pieces of iron placed in other boxes, and these two grades of shot melted in separate heats.

The larger shot, among which were pieces weighing from

one ounce to four or five pounds, when melted and run into pig showed a close mottled iron with an even crystal throughout the fracture.

The pig was too hard to drill freely, and the half-inch plate cast from this iron could not be touched with the drill; this iron was designated No. 2 foundry pig.

The small shot was next melted and poured into pig, which, when broken, showed a white iron in various parts of the pig, with no crystalization and very hard and easily broken. This was designated No. 3 foundry pig.

The tests were made in a foundry making light castings, and using soft iron, and all the shot was made from this grade of iron. The per cent of iron lost in melting the different grades of shot described varied from 10 to 50 per cent. The lightest loss was in the new shot, and the heaviest in the very small rusted shot.

These tests showed that rusted shot produced a hard iron, and the degree of hardness varied with the extent to which the shot was rusted. The small particles, which were almost entirely destroyed with rust, produced a harder iron than the larger shot, in which a considerable body of iron had not been affected by the rust. It also showed that the iron from heavily rusted shot would not unite with iron from larger shot to produce a homogeneous iron in a pig.

That iron from rusted shot is not softened by melting it with soft iron was shown later on in melting small rusted shot with a very soft No. 1 iron. In this test, an equal weight of shot and pig were charged and run into pig and also into light castings. The pig when broken showed a very uneven crystalization in the fracture. In some parts it was very open and soft, in others very close and hard, showing the two irons would not unite in a heavy casting to produce an even iron. In the thin castings, in which the iron had been suddenly cooled, the iron from the shot was white and in some places had separated from the soft iron and sandwiched in between two layers of soft iron. In thicker castings it had separated and formed in small nodules.

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These same phenomena have also been observed in other foundries when melting shot with other irons, and also when melting pig made from shot with other irons, showing conclusively that one of the causes of hard spots in castings is rusted shot iron, and that hard spots are not prevented by melting shot at the end of a heat and running it into pig before melting with other iron.

Many careless molders never remove scrap from the top of molds before shaking out, and seldom throw out riddlings, until the sand heap becomes so filled with small scrap that it is no longer fit for molding. Scrap from top of molds and also riddlings are thrown in a corner or any out of the way place, where they are permitted to remain for months. Gangways and also molding floors are frequently permitted to fill up with scrap and sand and only cleared and scrap recovered once in six months or a year. This scrap is heavily coated with rust and many of the small pieces are almost entirely destroyed with it.

To recover this iron, it is necessary to riddle all the refuse, or pass it through a separator, and in some cases to dry it before so treating. In few, if any, cases is the iron recovered of sufficient value to pay the wages of men for time employed in recovering it.

It is more economical to throw all this refuse in the dump, only recovering the larger pieces of iron as they may chance to be presented to view. When gangways are cleaned every day, a better grade of shot is recovered, but in this shot badly rusted scrap from the sand heap riddlings are found. These, when melted with new shot, produce hard spots; their hardening tendency can be removed to some extent, but not fully by tumbling to remove the rust, but it will probably be found more profitable when only fine work is made, to provide a place for sand heap riddlings and consign them to the dump.

I have not had a sufficient experience in melting shot iron with a ferro silicon iron, claimed to produce a soft casting with 90 per cent of scrap, to accurately indicate results. This iron may restore to shot the properties removed by rusting, and en-

able the founder to profitably utilize all this class of iron, without risk of impairing the quality of his casting by hard spots.

In trying this, the shot and ferro silicon iron should be drawn from the cupola together into a large ladle to give the two grades of iron an opportunity to mix, and the iron should be well stirred before pouring. New shot from the dump and gangways mix with other iron when melted with it, and probably the best way to melt them is to distribute them through the heat, placing a small amount in the cupola with each charge of iron and in this way melting in each heat all the shot from the former heat. In describing this iron, to which the term oxidized iron is also applied, the term rusted has been used, for the reason that it is the term most commonly used in foundries, hence more readily understood by those most interested in foundry irons. And, also because the term oxidized is also applied to burned iron, and is therefore misleading.

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